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Forensic DNA phenotyping and its politics of legitimation and contestation: Views of forensic geneticists in Europe

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Abstract

Forensic DNA Phenotyping (FDP) is a set of techniques that aim to infer externally visible characteristics in humans – such as eye, hair and skin color – and biogeographical ancestry of an unknown person, based on biological material. FDP has been applied in various jurisdictions in a limited number of high-profile cases to provide intelligence for criminal investigations. There are on-going controversies about the reliability and validity of FDP, which come together with debates about the ethical challenges emerging from the use of this technology in the criminal justice system. Our study explores how, in the context of complex politics of legitimation of and contestation over the use of FDP, forensic geneticists in Europe perceive this technology's potential applications, utility and risks. Forensic geneticists perform several forms of discursive boundary work, making distinctions between science and the criminal justice system, experts and non-experts, and good and bad science. Such forms of boundary work reconstruct the complex positioning vis-à-vis legal and scientific realities. In particular, while mobilizing interest in FDP, forensic geneticists simultaneously carve out notions of risk, accountability and scientific conduct that perform distance from FDP' implications in the criminal justice system.

Keywords

forensic DNA phenotyping, biolegality, boundary work, legitimation

Introduction

Forensic DNA Phenotyping (FDP) can be broadly described as a set of techniques that aims to infer externally visible physical features in humans – eye, hair and skin

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color – and biogeographical ancestry of criminal suspects, through analysis of biological materials collected at crime scenes (Kayser, 2015; Kayser and de Knijff, 2011; Kayser and Schneider, 2009; Liu et al., 2015).[1] FDP technologies have been applied in various jurisdictions in a limited number of high-profile cases (Wienroth, 2018: 4) to provide intelligence for criminal investigations, providing information relevant to specific targets (Innes et al., 2005: 42).

In 2003, the Netherlands was the first country to explicitly regulate the use of FDP (M'charek, 2008). Now, the country allows testing for sex, biogeographical ancestry, and hair and eye color (Hopman, 2020; Hopman and M'charek, 2020; Samuel and Prainsack, 2018). In Slovakia, testing for 'visible phenotypic traits' is also allowed (Samuel and Prainsack, 2019). By the end of 2019, Germany also approved the prediction of externally visible characteristics such as hair, eye and skin colour, as well as age. Within Germany, Bavarian Police Law has also tested for biogeographical ancestry since 2018. In other European countries, there is implict or absent legislation regarding FDP. Such legal vacuums therefore lead to varying interpretations about the use of FDP in the criminal justice system (Samuel and Prainsack, 2018) which, in somes cases, implies that decision-making is placed within local forensic users (Wienroth, 2018).

FDP represents a historical change in the presence of forensic genetic technologies in the criminal justice system. First, it shifts the focus of forensic science from the construction of evidence towards the generation of intelligence valuable to criminal investigations (Wienroth, 2018). Second, FDP moves the locus from individualization, that is, the identification of specific individuals, towards collectivization by clustering 'suspect' populations that share genetic ancestry and/or externally visible characteristics (Hopman and M'charek, 2020; M'charek, 2020). It is a process that Cole (2018: 2) describes as the 'convergence of individual and collective identification'. Third, FDP uses single nucleotide polymorphisms (SNPs). Such genetic markers are characterized by informational richness and enroll appearance and race in the field of forensic genetics (M'charek et al., 2014; Schwartz-Marín et al., 2015). This stands in opposition with DNA profiling and DNA databasing techniques that make use of autosomal short tandem repeats. These so-called 'non-coding genes' presumably hold little value other than identification (Cole, 2007) and are seen as inherently independent of phenotypical associations (Hopman and M'charek, 2020; M'charek, 2020; M'charek et al., 2020), thus avoiding accusations about racial prejudice (Schwartz-Marín et al., 2015: 864). In this domain, it is particularly relevant to problematize how the genetic reinscription of race (El-Haj, 2007) might play out in the everyday practices of criminal investigations, how socially constructed notions of 'race' and 'ethnicity' might be translated into biological characteristics and vice-versa (Hopman and M'charek, 2020; M'charek, 2020; M'charek et al., 2020; Toom et al., 2016). Researchers have recently explored how forensic experts perceive the visibilities and invisibilities of race in FDP (Queirós, 2019) and how FDP translates and catalyzes significant changes in the use of race as an object of expert knowledge in science and policy-making (Skinner, 2018a, 2018b).

With the advent of investigative forensic technologies such as FDP, forensic genetics is in a transitional state. On the one hand, forensic geneticists' work sustains widely disseminated notions of the symbolic power of DNA to solve criminal cases (Lynch et al., 2008), and maintains forensic genetics' consolidated evidentiary role in the criminal

justice system. On the other hand, FDP demands that forensic geneticists deal with a range of potential interpretations accompanied by little guidance (Wienroth, 2018). Therefore, new values, norms and consensuses have to be created for this technology to achieve credibility and objectivity.

In this article, we aim to understand how, in a context framed by complex politics of legitimation and contestation (Skinner, 2018a), forensic geneticists in Europe perceive FDP's potential applications, utility and risks. In the current transitional and transformative stage of forensic genetics, we argue that it is vital to understand how forensic geneticists frame FDP. These professionals have power to not only shape the regulation of such technology but also to influence the distribution of responsibilities between scientific and legal realms.

Previous work in Science and Technology Studies (STS) has explored the legitimation and contestation associated with uses of forensic genetics in the criminal justice system, particularly around controversies on the reliability and validity of DNA profiling technologies (Jasanoff, 1998, 2004; Lawless, 2012; Lynch, 2002; Lynch et al., 2008). This article focuses on the case of FDP, making use of the concepts of biolegality (Lawless, 2012; Lynch and McNally, 2009) and boundary work (Gieryn, 1983). According to Lynch and McNally (2009: 284), who coined the term,

> biolegality refers to how developments in biological knowledge and technique are attuned to requirements and constraints in the criminal justice system, while legal institutions anticipate, enable, and react to those developments. This ongoing process redefines the rights and status of the suspect body and the credibility of criminal evidence.

The biolegality framework is thereby two-fold. On the one hand, it highlights the complex traffic between legal and scientific categories and practices, to display how obstacles to the deployment of forensic DNA profiling and DNA databasing have been overcome to conform to the needs and constraints of the judicial legal system. On the other hand, it broadens the debate on biocitizenship (Rose and Novas, 2005) by drawing attention, in the context of forensic science, to technologies of social categorization, control and disciplining (Tutton and Levitt, 2010: 98). As outlined by Lynch and McNally 'biolegality produces "risky" suspects, "pre-suspects" and "statistical suspects". … One of the features of the biolegal marking of bodies is its potential to expand, driven by diverse logics, potentially encompassing entire populations' (Lynch and McNally, 2009: 284).

Previous literature on the presence of DNA technologies in the criminal justice system has revealed that complexity and messy elements are vital parts of forensic science (Derksen, 2000; Lawless, 2012; Lynch, 2002). Studies of the construction of the credibility and legitimacy of DNA profiling techniques have highlighted the construction of social boundaries of expertise and the distribution of responsibilities between the forensic geneticists and the work of other social actors in the criminal justice system (Kruse, 2013, 2016; Lawless, 2012). Hence, this study adopts the concept of boundary work, initially proposed by Gieryn (1983) and subsequently mobilized by several authors critically exploring the field of forensic genetics (Kruse, 2016; Lawless, 2012; Machado and Granja, 2018) to explore how forensic geneticists perform discursive boundary work concerning FDP.

While biolegality draws attention to the complex unfolding traffic between legal and scientific categories and practices, boundary work underlines attempts to demarcate and draw boundaries. Our study thereby reveals how the ongoing reframing of biolegality shows a call for renewal and, in some cases, fortification of certain boundaries, precisely because it disturbs pre-established distinctions on which forensic geneticists based their work. The discursive boundary work enacted by forensic geneticists between science and criminal justice system, experts and non-experts, and good and bad science allows such professionals to reconstruct the complex positioning vis-à-vis legal and scientific realities. More particularly, while mobilizing interest in FDP, forensic geneticists simultaneously carve out notions of risk, accountability and scientific conduct that perform distance from FDP's implications in the criminal justice system.

Methods

This article is based on a broader project that explores the societal, cultural, ethical, regulatory and political impacts of the use of forensic DNA technologies in the European Union (EU). Empirical material derives from 29 interviews conducted with forensic geneticists based in thirteen different European countries between March 2016 and May 2018. We have been following FDP during a period in which several controversies were being debated[2] and several others were emerging. As a result, interviewees responses reflect their views and positionings concerning the on-going complex politics of legitimation and contestation that frame the use of FDP in the criminal justice system.

All of our interviewees possess a degree in a discipline that is directly connected to forensic genetics (e.g. biology, genetics and medicine). Considering the diversity of the forensic genetics community (Cole, 2013), participants hold variable positions and responsibilities. Five interviewees are solely engaged with case-work; they conduct laboratory work on criminal cases, work closely with police forces engaged in criminal investigations and/or act as expert witnesses before courts. Ten are research-oriented scientists, individuals employed by universities and conducting research the application of which is in the field of forensic science. In the case of fourteen participants, such positions are interchangeable insofar as forensic genetics professionals in the European Union can simultaneously develop research activities and be engaged in casework. Individuals who perform research-related activities, either exclusively or complemented with casework, are also usually involved in several advisory committees, consultancy work, and international research-oriented networks.

The interviews were conducted within the framework of the protocols and procedures of the European Research Council's ethics regulations. Participants were recruited by email, letter and telephone calls. Before the interviews, all interviewees signed a written informed consent form and agreed to be audio recorded. Twenty of the interviews occurred in the workplaces of the participants, six were made via Skype, two took place during a forensic science conference and one interview was conducted via phone call. On average, the interviews were 90 minutes long. The interviewers took notes to help guide questions in the interview and for reflection afterward. All interviews were digitally recorded, transcribed verbatim and anonymized. Editing of the quotations was carried out when necessary to assure clarity of language, while fully respecting the meaning

manifested by the participants' words (Bertaux, 1997). To protect the anonymity of the interviewees, the country in which each interviewee was based was identified using a letter. This form of anonymization will be used in the interview quotations analyzed in the following sections.

The script of the interviews covered the following themes: the organization of forensic genetics services in the country in which the participant was based, views and experiences regarding the transnational exchange of DNA data in the EU, representations of public engagement with forensic genetics, and perceptions of DNA technology developments and innovations, such as FDP. For this article, we explore only the interviewees' views concerning FDP. To avoid narrowly framing the topic under analysis, we refer to the term 'forensic DNA phenotyping', although for the analysis pursued herein, we also identify other terms relating to the genetic technology used, such as 'externally visible characteristics', 'biogeographic ancestry', 'ancestry informative markers' and 'extended DNA analysis'.

Relevant quotations were coded and subjected to multiple readings to develop an in-depth understanding of the views of forensic geneticists. These quotations were systematically compared, contrasted, synthesized and coded by theme and thematic category following the principles of grounded theory (Charmaz, 2006; Glaser and Strauss, 1967; Strauss and Corbin, 1990) and interpreted using a qualitative content analysis approach (Mayring, 2004). In this paper, we analyze the replies that were considered by both authors as illustrative of each thematic category that emerged from the content analysis.

Boundary work: Science and the criminal justice system

The expansion of the scope of forensic genetics to incorporate technologies that go beyond identification purposes does not come without collateral consequences related to the negotiation of its scientific legitimacy and validity. As with other DNA technologies, FDP is anchored on probabilistic statistics (Caliebe et al., 2017; Hopman and M'charek, 2020; Kayser, 2015). As a result, there is an epistemic risk – degrees of certainty or uncertainty associated with the interpretation of forensic DNA technologies (Lawless, 2010: 381) – that must be considered and managed in the use of FDP in criminal cases. Such epistemic risk is even more prominent in the case of FDP, since other DNA technologies, such as DNA profiling, are usually characterized by higher probabilistic values:

> The geographical origins or phenotypical traits can be helpful to the investigation, but we need to pay attention to the ranges where we operate in terms of errors … we have to be prudent in that area since we're coming from a very routine technique. [C01 – works both with casework and research]

> FDP probability is usually not as high as you are used to in the DNA profiling. It's usually, let's say, around 80 to 90-something per cent but it's not near 100%. [O08 – researcher]

Participants thereby renegotiate epistemic risk not as something that precludes the use of FDP in the criminal justice system, but as an inevitable and unavoidable element of scientific practice (Lawless, 2012: 204). According to their views, intelligence for

criminal investigations might have a lower threshold of validity and reliability, since it will be used to guide an investigation to find more robust evidence (Lawless, 2016: 136). Forensic geneticists thereby engage with a distinction that delineates the spaces where the epistemic risk is considered to be acceptable and manageable (scientific and investigative procedures), and the spaces from which it should be excluded (sentencing procedures):

> A test in an investigative context is exploratory, [it is] where the police look for clues in order to apprehend a suspect or narrow down the list of suspects. They don't need to be 100% valid in scientific terms, as it cannot be used as evidence when testifying. [C05 – researcher]

In this sense, instead of black-boxing FDP by closing down sources of controversies (Latour, 1987), forensic geneticists create what Kruse calls a 'semi-transparent box … neither fully opaque nor fully transparent' (Kruse, 2016: 115) in which the epistemic risks associated with FDP are left visible and to be solved by others. This approach implies a specific type of discursive boundary work between science and the criminal justice system: forensic geneticists decouple the need to maintain scientific propriety (in which uncertainty is an integral part of scientific practice) and the need to determine justice (in which propositions must be supported by clear-cut arguments and robust evidence).

The decoupling of the demands of science and law is also mobilized by forensic geneticists to respond to one of the most relevant issues within the politics of legitimation and contestation regarding FDP, namely, its perceived ethical implications. As widely discussed by social scientists studying the ethical implications of FDP, such technology has the power to generate a new set of collective suspects in ways that might reproduce stigmatization and criminalization (M'charek, 2008; Sankar, 2010; Skinner, 2018a; Toom et al., 2016). Such stigmatization and criminalization mainly targets racialized populations, as FDP contributes to reinforcing racial categories (Hopman and M'charek, 2020; M'charek, 2013, 2020; M'charek et al., 2020). Taking into consideration the possibility of perpetuating social prejudice through the use of FDP in the criminal justice system, forensic geneticists argue that what might be considered as prone to risks of stigmatization and exacerbation of criminalization is not the forensic test *by itself* but the subsequent actions that other actors – such as police forces – enact on the basis of such information.

> It can happen that police investigations are led toward a certain group of people, yes, but it can also lead away from certain group of people; and it can lead towards the vulnerable people but also away from vulnerable people. … I don't want to say that there is no risk of racial profiling within the police, I think that this is a completely different discussion and it's a discussion that the police needs to have. … But the risk is completely separated from the way we [forensic geneticists] type the sample. [O13 – works both with casework and research]

By drawing boundaries between the spheres of action of science and the criminal justice system, forensic geneticists thereby negotiate the nature and limits of epistemic responsibility related to the ethical controversies of FDP. While acknowledging the potential discriminatory issues that FDP might exacerbate, responsibility is placed in relief against the wider domain in which it operates, that is, anchored in longstanding structures of power and inequality that affect, in a particularly visible form, the interaction between police forces and racialized minorities (Skinner, 2018b).

Boundary work: Experts and non-experts

The communication and interpretation of information produced by FDP attract considerable discussion among forensic geneticists, especially as many of the particularities of communicating forensic genetics to non-expert publics (Amelung et al., 2020; Amorim, 2012) are intensified in the case of FDP. Sustaining the distinction between scientific and non-scientific domains, in which forensic geneticists are considered as scientific experts and all other actors – such as police forces and the general public – are non-experts, most interviewees express significant concerns about how non-experts show overly positive expectations concerning FDP. According to the forensic geneticists who participated in our study, there are a series of commercial, entertainment and media interests exaggerating the potential uses of FDP:

> I think sometimes some scientists, [private, commercial] companies, and the media, tend to hype up these things and put a spin on them and present them in a certain way which greatly exaggerates their potential. [D11 – researcher]

Such overstated potential of FDP is considered by our interviewees as further complicated when it directly influences members of the criminal justice system, such as police forces. Coupled with possible knowledge deficits about the particularities of DNA technologies (Amorim, 2012; Amorim et al., 2016; Gill, 2016), overly enthusiastic views over FDP possibilities might generate several challenges in the communication between forensic geneticists and police forces. In this respect, interviewees often describe how they have to deal with frustration and disappointment from police forces when the limitations of FDP are explained:

> Some [police officers] are influenced by scientific magazines, … which present forensic DNA phenotyping as something spectacular, where everything can be known, and they get depressed when you tell them what you can and can't do. [C05 – researcher]

> We quite often get asked by police investigators to try and distinguish somebody from the Middle East, or North Africa, from people from Europe. And that is not as easy, always, as people would think. So, we have the ethical issue of police expectations before we do the test. They make a lot of assumptions about the capacity of the genetic tests, because they watch CSI on television.[3] [C04 – works both with casework and research]

Confronted with such scenarios of exaggeration about the capabilities of FDP, forensic geneticists consider that the main way of avoiding or diminishing the effects of such hype would be to present information about the limitations of FDP. Participants of this study assert that if interested publics, especially those who directly deal with such results, understand the contingencies involved, risks of misuse would be diminished.

Consequently, as a response to the perceived 'misconceptions' concerning FDP, forensic geneticists actively engage in managing expectations by communicating both the potential and limitations associated with the technology. Such a position has been increasingly entering the 'epistemic toolkit of science' (Bliss, 2012), which ensures the legitimacy of scientific knowledge and practice and is increasingly anchored on notions of accountability and transparency (see also Machado and Granja, 2018). Forensic

geneticists thereby engage with a (re)shaping of accountability by expressing assumptions about 'how individuals and groups should and shouldn't interact, and about the proper distribution of work between different professional groups' (Goodwin, 2018: 104). In this sense, accountability is configured and distributed across various entities as an enactment of particular relations of power (Yakel, 2001) in ways that (re)create inclusions and exclusions.

In such biolegal contexts, where multiple actors interact and where the social, scientific and technical are irredeemably bonded together (Kruse, 2010), forensic geneticists configure accountability as two-fold. Firstly, they consider themselves accountable for accurately and transparently communicating the potentialities and risks of FDP – that is, making the research, methods, data, procedures and findings publicly available. Such position is explained by the following interviewee, who argues that the communication of the possibilities and limitations of genetic technologies such as FDP constitutes as an integral part of forensic geneticists' 'scientific role' in society:

> Expectations are too big for this technology [FDP]. There is an over expectation for what we can achieve using the new technologies, at the time being. That is my role, as a scientist, to explain what is possible and what are the limitations. [O01 – works both with casework and research]

In other words, accountability entails not only the fulfillment of technical requirements in laboratory work but also the management of public expectations of performance, responsiveness and morality (Yakel, 2001). Such enactments of accountability thereby end up functioning to protect forensic geneticists' roles by projecting an image of scientists as engaged with the societal implications of their work:

> What we can do is we can attend the important meetings and we can give our point of view. … So, to just bring the discussion down to a more realistic view on this rather than it to be over expectant or just to you think of forensics geneticists as the new Frankenstein who just do whatever they can and don't care about ethics or don't care about vulnerable people. [O13 – works both with casework and research]

A second configuration of accountability is done by diffusing and distributing responsibilities. One of the ways of doing that is by outlining how collective forms of accountability can only work if all parts are equally engaged. As outlined in the following quotation, forensic geneticists argue that, for them to be successful in communicating both the potentialities and contingencies of FDP, other actors, such as police forces, must be willing to learn from them:

> The general things I could say is that when you progress science and you want non-scientists to either apply it or to be involved in any decision making afterward, they have to understand what the science is about. … Not only the basics, at best they should understand more if not all of it. And, of course, there is a responsibility for the scientists to explain and to teach, but there is also a responsibility from the other side to seek such knowledge, either by attending courses or by whatever. [A02 – works both with casework and research]

Another form of diffusing and distributing responsibilities relates to the interpretation of data. Most of the participants in this study argue that one of the most problematic issues of the concrete application of FDP results from a misunderstanding of its potential and situated uses, rather than issues of scientific reliability and validity associated with the technology itself. As also noted by Wienroth, forensic geneticists believe that 'while the investigative interpretation may err, the scientific analysis – if done correctly – remains neutral to the effects of the interpretation' (Wienroth, 2020: 10). Sustaining their discourses in a narrative of technical neutrality, forensic geneticists thereby place the responsibility of interpretation in police forces. That is, the uncertainties that were left visible in the semi-transparent box must, according to interviewees' views, be managed by police forces. Such a perspective is illustrated by the following interviewee explaining how forensic geneticists' communication with police forces is both anchored on managing overly enthusiastic expectations and on communicating the 'merely' indicative nature of results in a specific criminal case, that is, signifying that 'raw data' must be interpreted:

> I am also involved in a lot of communication with the law forces, and so to explain them what we do, and trying to convince them that it is just a result … and that the people in charge of the case need to take this information into account, but not take it blindly saying it is the truth. It must be interpreted in some way. [H03 – works both with casework and research]

Forensic geneticists understand their role as making themselves available to discuss results with non-experts, while they maintain a clear separation between their actions as experts and the subsequent interpretation of analysts of investigative crime scene samples (Amorim, 2012). This type of viewpoint thus conveys two interrelated forms of discursive boundary work – between science and the criminal justice system and between expert and non-expert publics – that are unstable and flexible. If forensic geneticists consider themselves accountable for clearly communicating data, they also argue that police forces must be accountable for its interpretation. Forensic geneticists, therefore, convey the notion that they are solely accountable – in the sense of being answerable – for accurately communicating results:

> I do phenotyping, and a few others are doing it as well. But, I mean, what we produce is only a verbal statement, very carefully explained and phrased, in order to provide the police with a basic idea of a limited number of features which could fit, with certain prediction accuracy, to the suspect they are looking for. And that is what you can do, not more and not less. [A03 – works both with casework and research]

Through a combination of carefully selected, scrutinized and edited record-keeping practices and writing techniques and the elaboration of conservative reports and sentences that underline the statistical nature of the findings (Yakel, 2001), forensic geneticists thereby shape their performances of accountability as restricted. Controversies over the meanings attributed to FDP are displaced from spaces of knowledge production and forensic genetics laboratories, and allocated to spaces of knowledge application: criminal investigations. A distinction between knowledge production and its applications and uses is deliberately maintained and generally accepted (Lynch et al., 2008), in ways that

protect the autonomy of science (Gieryn, 1983). Issues of validity and reliability of FDP are, therefore, not necessarily resolved but are rendered as manageable by configuring accountability in ways that 'manage the tension between inevitable uncertainty and the necessity to deliver meaningful results' (Kruse, 2013: 658).

Boundary work: Good and bad science

Ethical principles underpinning the application of forensic science are not immediately apparent (Lawless, 2016). As a result, forensic geneticists engage themselves with setting norms and values to assure that they comprise normative points of reference on how to make use of FDP in the criminal justice system adequately and legitimately – what Wienroth (2018) calls 'self-anticipatory practices'. In tandem with a boundary work between science and the criminal justice system and between experts and non-experts, the views of forensic geneticists about FDP are also sustained in a division between good and bad science. In such a framework, good science is perceived in the sense attributed by Thompson (2012), as science engaged with ethics: '"good science" … connotes the conduct of sciences that have ethics in ways that iteratively develop the science and ethics of their fields together to the mutually entwined and multiple ends of both robust science and technology, and the greater articulation and mitigation of problems of distributive or other injustice' (Thompson, 2012: 28).

One of the forms whereby forensic geneticists frame such ethically embedded science is by defending the selective use of FDP. That is, most interviewees agree that this technology should ideally be restricted to serious criminal cases that produce severe social consequences. Framing FDP as a technology that might provide useful insights when nothing else has worked (DNA profiling, DNA databasing and other 'traditional' avenues of criminal investigation), forensic geneticists connect the promissory value of FDP (Wienroth, 2018) to its potential positive social implications: solving, in ways that uphold public security and social justice, serious criminal cases that have caused serious harm to society. Forensic geneticists thus outline the technology's 'unique' ability to solve complex criminal cases. In the words of one of the participants:

> I think FDP should only be used for serious crimes, murders, rape, something like that… If I have a serious crime where there may even be a risk of repetition, that would be a case where I would be very much in favor of using it. But I cannot decide that alone and that must be weighed up by society, what society is willing to tolerate and where they absolutely want to have it solved. [O010 – researcher]

This statement is particularly illustrative of the two forms of public science at play in forensic geneticists' views. On the one hand, the interviewee describes science for the public good (Gieryn, 1983: 782), outlining FDP added value of solving serious crimes. In such a scenario, FDP is framed as serving the purposes of a type of public science that is responsive to public needs of security and justice. On the other hand, it is also clear that the interviewee account demonstrates how imaginaries of the public world – particularly, what is considered as ethically acceptable and socially legitimate – are accommodated in scientific knowledge and taken as an integral part of its generation. Such a proposition is

in line with Wynne's conceptualization of public science, defined as 'the sense of scientific knowledge in which we may identify such implicit human–public dimensions as part of the science itself' (Wynne, 2005: 68–69). Framing FDP as 'public science' thus represents a notable aspect of the biolegal production of suspects in action. Exceptional procedures, such as inferring ancestry and externally visible characteristics of an unknown suspect, become facilitated by discourses concerning the added value of this particular technology, in ways that both respond to and incorporate society's dominant views.

Coupled with the creation of a threshold of seriousness that defines the types of criminal cases in which should FDP be used, interviewed forensic geneticists also suggest that specific restrictions should be in place regarding the type of data that may be extracted based on genetic testing. Considering the scarce formalized ethical guidance in place for the forensic uses of FDP, as ethical guides for genetic testing tend to be directed towards medical uses (Lawless, 2016: 137), interviewed forensic geneticists assume the epistemic responsibility of defining such perimeters:

> I think [FDP] should also be done only in serious crime cases. Like capital crime cases, where there is a very urgent public interest to identify the perpetrator. So, there should be a threshold for the level of the crime, there should be a clear red line in terms of what can be tested and what cannot be tested in terms of genetics. [O01 – works both with casework and research]

The distinctively informative potential of genetic data (Williams and Johnson, 2004) and the historical reputation of linking genetics to social problems (see Duster, 2003) sustain, at least partially, the positioning expressed by the participants. In the case of FDP, good forensic science entails looking to characteristics considered to have a public character, such as eye, skin and hair color. Bad forensic science goes beyond what is visible, that is, looking into character disorders and to diagnose certain types of 'dispositions'. According to one interviewee, although medical information might sometimes be considered useful by police forces eager to solve difficult criminal cases, most forensic geneticists do not consider it to be a legitimate use of the technology. As such, they disagree with using medical information for the specific purpose of criminal identification:

> If we just listen to people working on casework, then we would do medical prediction of diseases, because for them if you predict that some people have liver failure, for example, then it is very easy to track people with liver failure. But of course, it is very ethically wrong, because you look at very personal data that even the people may not have. … So, I would really restrict the list of externally visible characteristics that we should be able to do and exclude everything linked to medical. [H03 – works both with casework and research]

Another dimension of the boundary work established between good and bad science regards forensic geneticists' reactions to private companies' claims over FDP. In particular, participants in this study responded critically to the practices and proactive commercial behavior of Parabon Nanolabs,[4] a company commercializing a service called Snapshot (see also Wienroth, 2018). Snapshot is a tool that allegedly enables a prediction of the appearance, including face morphology, of an unknown individual.

One of the reasons why interviewees adopt a particularly critical stance towards Parabon Nanolabs is that the company commercially exploited data produced by leading

forensic geneticists. This kind of behavior creates a complex ethical conundrum between prerogatives of open data (Mayernik, 2017; Mirowski, 2018) and the commercialization of science:

> For facial prediction, Parabon is using the same markers for eye color, and hair color and skin color that everyone is using. And those things are correct, and they are OK. … [But] the rest of the markers, they claim that they are testing so many different genes for facial characteristics, shapes and whatever. … They are mixing something which is established with something that they do not disclose. … I am really in favor of using published data and using open source data. Once we have them, of course, companies can offer that service, I have no problem with that. [O01 -– works both with casework and research]

Policies towards transparency, partially fostered by open data policies, therefore interact in a complex manner with the commercial exploration of scientific knowledge.

Scientific knowledge produced by forensic geneticists engaged in research is publicly available data and is, as a result, available to everyone. However, the companies that make use of such research black-box their services through commercial logics of secrecy and patent control. According to interviewees, Parabon's services are particularly difficult to scrutinize, due to its proprietary data-mining analysis. Such actions raise considerable concern and criticism among forensic geneticists, who are precluded from assessing the scientific robustness of the services being offered.

> These private companies, they don't usually lay open their methods. They should lay open their methods such that we know what they can do and what they cannot do. Each method has got its limitations so that's quite natural. But if you don't know the methods, you wouldn't know the limitation and where to look at. [O08 – researcher]

As a result, by not responding to what interviewees perceive as the normative stances of good science (practices of transparency, peer-review validation, and reproducibility), the outputs produced by Parabon Nanolabs concerning FDP are considered to be scientifically unsound applications solely driven by commercial interests. Such a point of view is clearly illustrated in the following quotation, in which an interviewee constructs a divide between the practices of the scientific community of forensic geneticists and private companies, respectively corresponding to good and bad science examples:

> What we do is to apply scientific methods which have been validated by research groups. … For private companies it is different because all of their models are based on economic purposes. And so, when you look at companies like Parabon, they predict face morphology, which for me is really wrong because there is not any scientific background behind it, nothing has been published, nothing has been validated by the scientific community, so it is more or less like a black box. [H03 – works both with casework and research]

Participants of this study frame the activities of Parabon as situated in a 'political economy of hope' (Petersen and Seear, 2011), which commercializes products by greatly extrapolating their potential, without being subject to any kind of independent validation. Forensic geneticists depict this kind of commercialization as a kind of scientific decay, a distortion of the scientific process. As outlined by the following participant, such situations

exacerbate concerns about the potential adverse impacts that Parabon and similar services might case on public perception of FDP and, by extension, on the public trust in science:

> They offer a service which is based on expectations and hopes. The question is: can they deliver anything useful? I think they cannot. … And I am a little bit worried that they are doing a disservice to the scientific community. Because they are offering something that does not exist. … The main point is that there is no scientific validation for that technology. …. And so I am a bit worried because if you were a scientist you would not do that. [O01 – works both with casework and research]

Enacting a discursive boundary between good and bad science, forensic geneticists thus construct considerations of scientific legitimacy that recognize potential conflicts between, on the one hand, standards of good science and, on the other, investigative priorities, commercial practices and interests. Within a context shaped by complex politics of legitimation and contestation over FDP, forensic geneticists adopt a position that emphasizes standards of scientific conduct. Such a position simultaneously legitimizes their way of producing scientific knowledge and re-asserts the social boundaries of expertise and authority of the scientific community of forensic geneticists.

Conclusion

In our interviews, forensic geneticists' views around FDP have striking similarities, overstepping national specificities regarding the regulation and situated use of FDP. That is, forensic geneticists' views on FDP are embedded in a community-specific web of signification that produces common views about the places and roles that FDP can take in criminal justice systems and how it should be developed in scientific fields. In this sense, despite the internal diversity of forensic geneticists' situated positions – in terms of the weight of sociohistorical and technopolitical backgrounds, available resources, legislative frameworks, and type of work conducted – there is a clear transnational character of certain emerging biolegal 'zones'. Such biolegal 'zones' might derive from both informal and formal alliances, such as research networks, that overstep national boundaries to reinforce the credibility of scientific assertions and re-assert boundaries of expertise. Within a context in which forensic science is undergoing a transformative state, forensic geneticists find themselves reconstructing complex positionings vis-à-vis judicial and commercial interests, while competing for the monopoly on legitimate knowledge. In other words, the historical change in the presence of forensic genetic technologies in the criminal justice system, here illustrated through the particular case of FDP, outlines the construction of a semantic continuum across national context in which biolegality is actively reframed.

The unfolding traffic between legal and scientific categories and practices, because it disturbs pre-established distinctions on which forensic geneticists have based their work, produces calls for the renewal of and sometimes even the fortification of certain boundaries. Besides creating distinctions between scientific and non-scientific domains – by delineating between the domains of science and of the criminal justice system and outlining differences between expert and non-expert publics – forensic geneticists also perform discursive intra-scientific boundaries by distinguishing between what they consider as being good and bad science.

The boundary work enacted between science and the criminal justice system takes several forms. First, it reflects the intentions of delimiting the scientific validity and reliability of FDP by constructing it as an investigative technology endowed with epistemic risk. Portraying such risk as an inevitable and unavoidable element of scientific practice (Lawless, 2012: 204), forensic geneticists divide the spaces where epistemic risk, by being framed into a 'semi-transparent box' (Kruse, 2013), is acceptable and manageable, and milieus whereas such risk must be excluded, such as sentencing procedures. At the same time, such boundary work between science and the criminal justice system also discloses forms whereby forensic genetics responds to the complex politics of legitimation and contestation over FDP. By decoupling the prerogatives of science and law, forensic geneticists locate FDP's potential to reproduce stigmatization and criminalization in the longstanding structures of power and inequality that affect the interaction between law enforcement and racial minorities.

Coupled with the discursive boundary work performed between science and the criminal justice system, forensic geneticists also draw distinctions between expert and non-expert publics. Here, interviewees configure accountability in a complex and convoluted manner. On the one hand, forensic geneticists consider themselves accountable for accurately communicating the limitations, risks and added value of FDP. On the other hand, accountability for interpreting data is diffused into the realm of the criminal justice system, in particular assigned to police forces. That is, according to the participants in this study, the uncertainties that are left as visible in the semi-transparent box must be managed by police forces. Responsibility is thereby displaced from the production of knowledge towards its uses and applications.

Finally, forensic geneticists perform a form of discursive boundary work anchored on notions of good and bad science. According to their narratives, good scientific conduct is anchored in a type of public science that both responds to and incorporates public needs for security and justice, as well as society's dominant views on what is considered as ethically acceptable and socially legitimate. The enactment of good science also implies adopting a position that sets standards of scientific conduct over judicial and commercial interests. In particular, forensic geneticists argue in favor of creating restrictions regarding the type of data that may be extracted based on genetic testing, even if such data would be considered of interest by law enforcement. Participants in this study also perform discursive boundary work between what they consider scientifically sound and unsound developments of FDP. The first corresponds to practices involving transparency, peer-reviewed validation, and reproducibility. Unsound science involves the commercial exploration of FDP and its associated lack of transparency. In this regard, participants outline the role of the company Parabon, which, in forensic geneticists' view, represents a kind of decay. Being managed according to the commercial logic of secrecy and anchored in a political economy of hope, the practices and proactive commercial behavior of Parabon are seen as potentially causing adverse effects on the public perception of FDP.

In sum, our article outlines how, within a context where the biolegal production of suspects compounds evidence and intelligence and converges individual and collective identification, forensic geneticists perform several forms of discursive boundary work while attempting to reconstruct the complex positioning vis-à-vis legal and scientific realities. In particular, while mobilizing interest in FDP, forensic geneticists simultaneously

carve out notions of epistemic risk, accountability and scientific conduct that perform a relative bounded distance from FDP's implications in the criminal justice system.

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Notes

1. For this article, we are excluding the potential uses of FDP in the search and/or identification of missing persons.
2. In this regard please see the discussions held in a leading forensic genetics journal between the forensic geneticists Kayser and Schneider (2009, 2012) and a group of social scientists (M'charek et al., 2012; Toom et al., 2016) and several others since then (Buchanan et al., 2018; Caliebe et al., 2018; Staubach et al., 2017).
3. The interviewee is making a direct reference to the so-called 'CSI effect', a concept employed by several scholars, and increasingly also practitioners and public media, that aims to capture how exaggerated views on the potential of DNA technologies are influenced by the wide popularity of techno-centric crime drama series on TV (Cole and Dioso-Villa, 2007; Podlas, 2006; Robbers, 2008).
4. Parabon Nanolabs provides a wide range of DNA analysis services. More information on the company can be found on this website: https://parabon-nanolabs.com (last access 1 June 2020).

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